TABLE 1-continued

Engine	Thrust SLTO (lbf)	Turbine section volume from the Inlet	Thrust/turbine section volume (lbf /in³)
4	33,000	6,745	4.84
5	96,500	31,086	3.10
6	96,500	62,172	1.55
7	96,500	46,629	2.07
8	37,098	6,745	5.50

Thus, in example embodiments, the power density would be greater than or equal to about 1.5 lbf/in³. More narrowly, the power density would be greater than or equal to about 2.0 lbf/in³. Even more narrowly, the power density would be greater than or equal to about 3.0 lbf/in³. More narrowly, the power density is greater than or equal to about 4.0 lbf/in³. Also, in embodiments, the power density is less than or equal to about 5.5 lbf/in³.

Engines made with the disclosed architecture, and including turbine sections as set forth in this application, and with modifications within the scope of this disclosure, thus provide very high efficient operation, and increased fuel efficiency and lightweight relative to their thrust capability.

An exit area 112 is defined at the exit location for the high pressure turbine 54 and an exit area 110 is defined at the outlet 106 of the low pressure turbine 46. The gear reduction 48 (shown in FIG. 1) provides for a range of different rotational speeds of the fan drive turbine, which in this example embodiment is the low pressure turbine 46, and the fan 42 (FIG. 1). Accordingly, the low pressure turbine 46, and thereby the low spool 30 including the low pressure compressor 44 may rotate at a very high speed. Low pressure turbine 46 and high pressure turbine 54 operation may be evaluated looking at a performance quantity which is the exit area for the respective turbine section multiplied by its respective speed squared. This performance quantity ("PQ") is defined as:

$$PQ_{ltp}=(A_{lpt} \times V_{lpt}^2)$$ Equation 1:

$$PQ_{hpt}=(A_{hpt} \times V_{hpt}^2)$$ Equation 2:

where A_{lpt} is the area 110 of the low pressure turbine 46 at the exit 106, V_{lpt} is the speed of the low pressure turbine section; A_{hpt} is the area of the high pressure turbine 54 at the exit 114, and where V_{hpt} is the speed of the high pressure turbine 54. As known, one would evaluate this performance quantity at the redline speed for each turbine section.

Thus, a ratio of the performance quantity for the low pressure turbine 46 compared to the performance quantify for the high pressure turbine 54 is:

$$(A_{lpt} \times V_{lpt}^2)/(A_{hpt} \times V_{hpt}^2)=PQ_{ltp}/PQ_{hpt}$$ Equation 3:

In one turbine embodiment made according to the above design, the areas of the low and high pressure turbines 46, 54 are 557.9 in² and 90.67 in², respectively. Further, the redline speeds of the low and high pressure turbine 46, 54 are 10179 rpm and 24346 rpm, respectively. Thus, using Equations 1 and 2 above, the performance quantities for the example low and high pressure turbines 46,54 are:

$$PQ_{ltp}=(A_{lpt} \times V_{lpt}^2)=(557.9 \text{ in}^2)$$
$$(10179 \text{ rpm})^2=57805157673.9 \text{ in}^2 \text{ rpm}^2$$ Equation 1:

$$PQ_{hpt}=(A_{hpt} \times V_{hpt}^2)=(90.67 \text{ in}^2)$$
$$(24346 \text{ rpm})^2=53742622009.72 \text{ in}^2 \text{ rpm}^2$$ Equation 2:

and using Equation 3 above, the ratio for the low pressure turbine section to the high pressure turbine section is:

$$\text{Ratio}=PQ_{hpt}/PQ_{hpt}=57805157673.9 \text{ in}^2 \text{ rpm}^2/$$
$$53742622009.72 \text{ in}^2 \text{ rpm}^2=1.075$$

In another embodiment, the ratio is greater than about 0.5 and in another embodiment the ratio is greater than about 0.8. With PQ_{ltp}/PQ_{hpt} ratios in the 0.5 to 1.5 range, a very efficient overall gas turbine engine is achieved. More narrowly, PQ_{ltp}/PQ_{hpt} ratios of above or equal to about 0.8 provides increased overall gas turbine efficiency. Even more narrowly, PQ_{ltp}/PQ_{hpt} ratios above or equal to 1.0 are even more efficient thermodynamically and from an enable a reduction in weight that improves aircraft fuel burn efficiency. As a result of these PQ_{ltp}/PQ_{hpt} ratios, in particular, the turbine section 28 can be made much smaller than in the prior art, both in diameter and axial length. In addition, the efficiency of the overall engine is greatly increased.

Referring to FIG. 11, portions of the low pressure compressor 44 and the low pressure turbine 46 of the low spool 30 are schematically shown and include rotors 116 of the low pressure turbine 46 and rotors 132 of the low pressure compressor 44. Each of the rotors 116 includes a bore radius 122, a live disk radius 124 and a bore width 126 in a direction parallel to the axis A. The rotor 116 supports turbine blades 118 that rotate relative to the turbine vanes 120. The low pressure compressor 44 includes rotors 132 including a bore radius 134, a live disk radius 136 and a bore width 138. The rotor 132 supports compressor blades 128 that rotate relative to vanes 130.

The bore radius 122 is that radius between an inner most surface of the bore and the axis. The live disk radius 124 is the radial distance from the axis of rotation A and a portion of the rotor supporting airfoil blades. The bore width 126 of the rotor in this example is the greatest width of the rotor and is disposed at a radial distance spaced apart from the axis A determined to provide desired physical performance properties.

The rotors for each of the low compressor 44 and the low pressure turbine 46 rotate at an increased speed compared to prior art low spool configurations. The geometric shape including the bore radius, live disk radius and the bore width are determined to provide the desired rotor performance in view of the mechanical and thermal stresses selected to be imposed during operation. Referring to FIG. 12, with continued reference to FIG. 11, a turbine rotor 116 is shown to further illustrate the relationship between the bore radius 126 and the live disk radius 124. Moreover, the relationships disclosed are provided within a known range of materials commonly utilized for construction of each of the rotors.

Accordingly, the increased performance attributes and performance are provided by desirable combinations of the disclosed features of the various components of the described and disclosed gas turbine engine embodiments.

FIG. 13 shows an embodiment 200, wherein there is a fan drive turbine 208 driving a shaft 206 to in turn drive a fan rotor 202. A gear reduction 204 may be positioned between the fan drive turbine 208 and the fan rotor 202. This gear reduction 204 may be structured and operate like the gear reduction disclosed above. A compressor rotor 210 is driven by an intermediate pressure turbine 212, and a second stage compressor rotor 214 is driven by a turbine rotor 216. A combustion section 218 is positioned intermediate the compressor rotor 214 and the turbine section 216.

FIG. 14 shows yet another embodiment 300 wherein a fan rotor 302 and a first stage compressor 304 rotate at a common speed. The gear reduction 306 (which may be